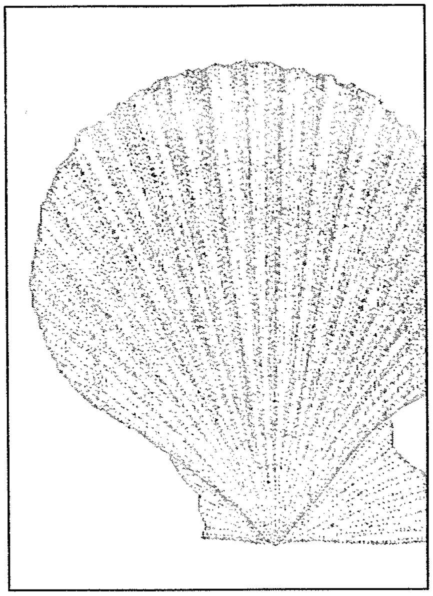
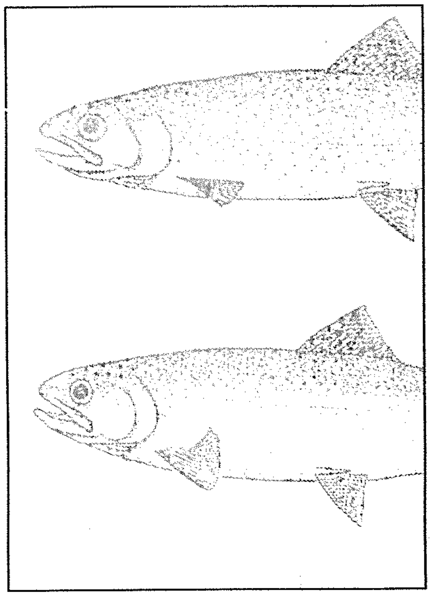
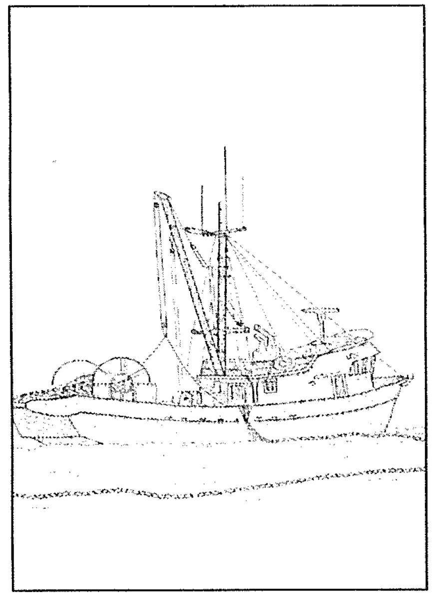
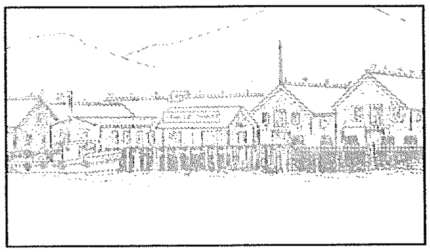
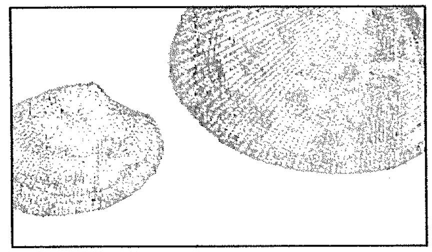
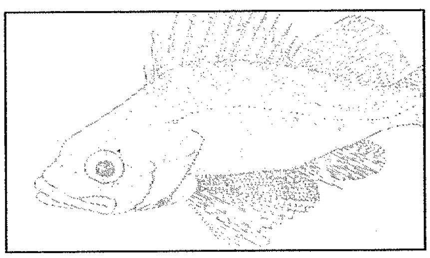
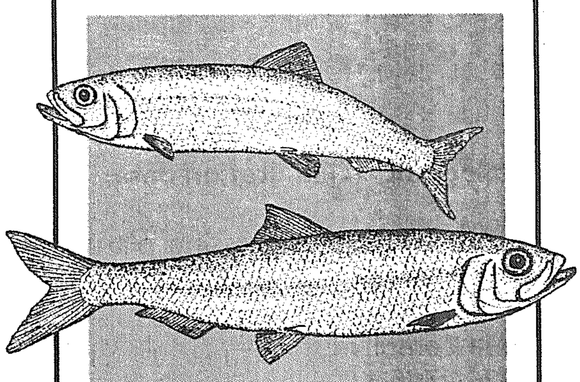
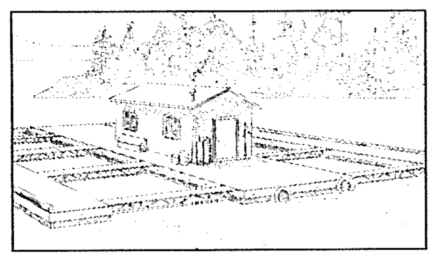
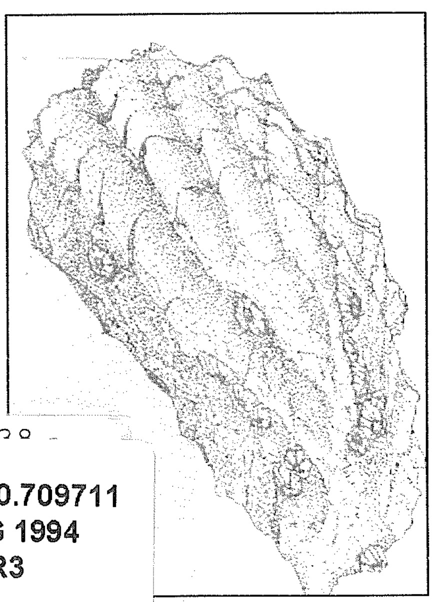
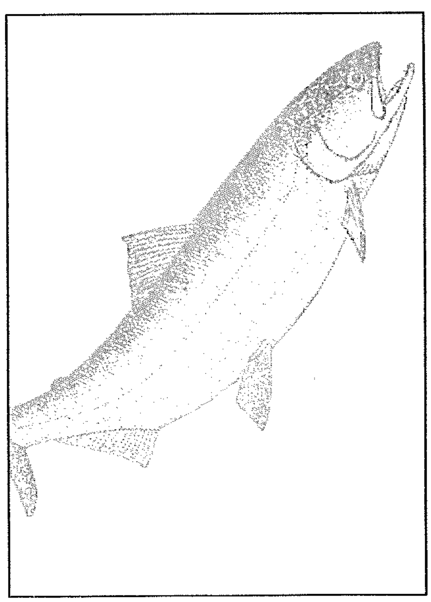
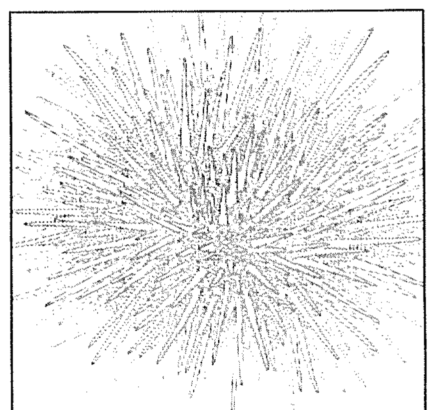




How to Do a Seafood Processing Plant Water, Waste, and Wastewater Audit

Province of British Columbia
Ministry of Agriculture, Fisheries and Food

Canadian Cataloguing in Publication data

Ismond, Alan.

How to do a seafood processing plant water, waste, and wastewater audit

"Aqua-Terra Consultants."

ISBN 0-7726-2366-X

1. Fishery processing industries — British Columbia. 2. Fishery processing industries — Waste disposal — British Columbia. I. British Columbia. Ministry of Agriculture, Fisheries and Food. II. Aqua-Terra Consultants. III. Title.

HD9464.C32B742 1994 338.4'766494'09711 C95-960056-6

Table of Contents

What Is a Seafood Processing Plant Audit?

All solids and liquids that come into and leave a fish processing plant are called streams (Figure 1). A processing plant audit is a method for measuring the amount of water and seafood solids in each of these streams. Like a car tune-up, a plant audit is a useful way to tell how efficiently the plant is operating. The audit indicates whether excess waste and wastewater are being created and also how much of the raw material is being converted into a saleable product.

Figure 1. Streams of a Fish Processing Plant

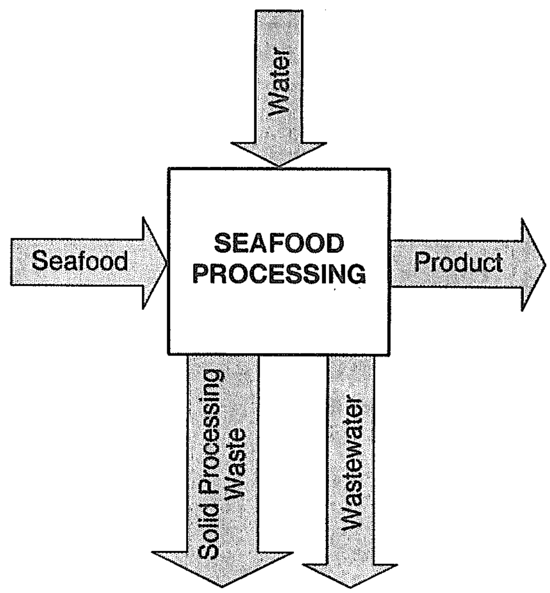
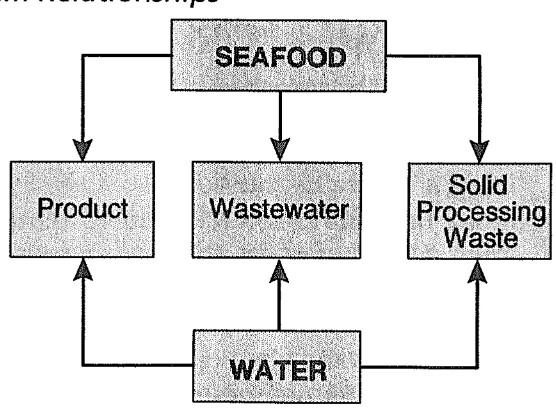


Figure 2 illustrates how seafood can end up in the product, wastewater and solid waste and how water can end up in both the wastewater and solid processing waste.

Figure 2. Stream Relationships



Why Do an Audit?

As shown in Table 1, each stream within a processing plant has an effect on the profitability of the plant. In addition to assessing the financial impacts various streams have, an audit can identify which equipment or practices in the plant use the most water and generate seafood solid waste and how efficiently incoming seafood, or raw material is converted into product. The audit information will help you identify which parts of the plant operations are using large quantities of water and which ones are contributing to the pollutant load. Furthermore, an audit will highlight the areas where the yield can be improved, and water, wastewater treatment, and solid waste disposal costs can be reduced.

Table 1. Financial Impacts of Processing Plant Streams

PROCESS STREAM	FINANCIAL IMPACT
Product	The greater the yield, or the percentage of the seafood brought into the plant that is converted to product, the more income the plant receives.
Water	There can be a cost for sourcing or producing quality water. The more water the plant uses, the greater the cost.
Wastewater	There is a cost for treating or disposing of wastewater. More water means more wastewater, and the greater the amount of seafood solids in the wastewater, the greater the cost for treating, recovering, or disposing of these solids.
Solid Processing Waste	This generally refers to fish heads, guts and frames, shells, etc. For most plants, there is a cost for disposal of these remains. The more water and non-recovered product in the waste, the greater the disposal cost.

An audit can cost between $1,000 and $10,000, depending on the size of the plant and whether outside help is needed. At present, the cost benefit can range from $10,000 to several hundred thousand dollars, and given the steadily increasing cost of water and waste disposal, the benefit will increase even more in the near future. The rising costs are primarily a result of government action to preserve resources and the environment. More and more, plant managers will need to examine plant operations and a thorough plant audit is the only way to accurately measure these disposal costs.

Who Should Do an Audit?

Because an audit will identify areas within the plant where efficiency and, therefore, profitability can be increased, every processing plant in operation can benefit from an audit. The employee or contractor who will do the audit should possess a thorough knowledge of:

- plant operations;
- how to sample waste streams;
- how to handle waste stream samples;
- how to send stream samples to a laboratory for analysis; and,
- how to measure flow rates.

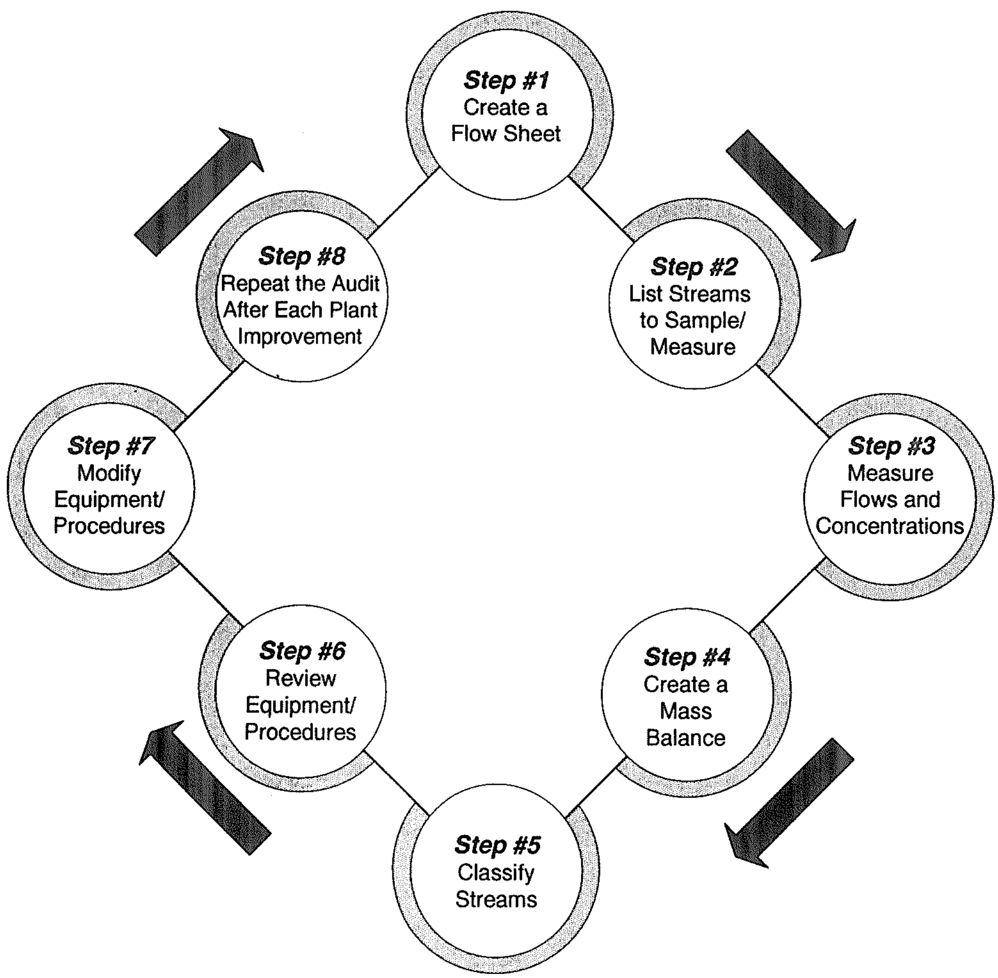
The accuracy and usefulness of a plant audit depends on the accuracy of the sampling and laboratory analysis. For the first audit, it may be worthwhile to hire an outside consultant who is familiar with each of the above processes. Once the procedure is established and documented, future audits can be done by plant personnel.

How to Do a Plant Audit

In general, a processing plant audit consists of the following eight steps outlined in Figure 3.

1. Create a flow sheet of the plant;
2. List the streams that must be sampled and measured;
3. Measure flows and concentrations;
4. Create a Mass Balance;
5. Classify the streams by flow rate and pollutant load;
6. Review plant equipment and practices and identify areas for improvement;
7. Modify equipment/operational procedures;
8. Repeat the audit after each plant improvement.

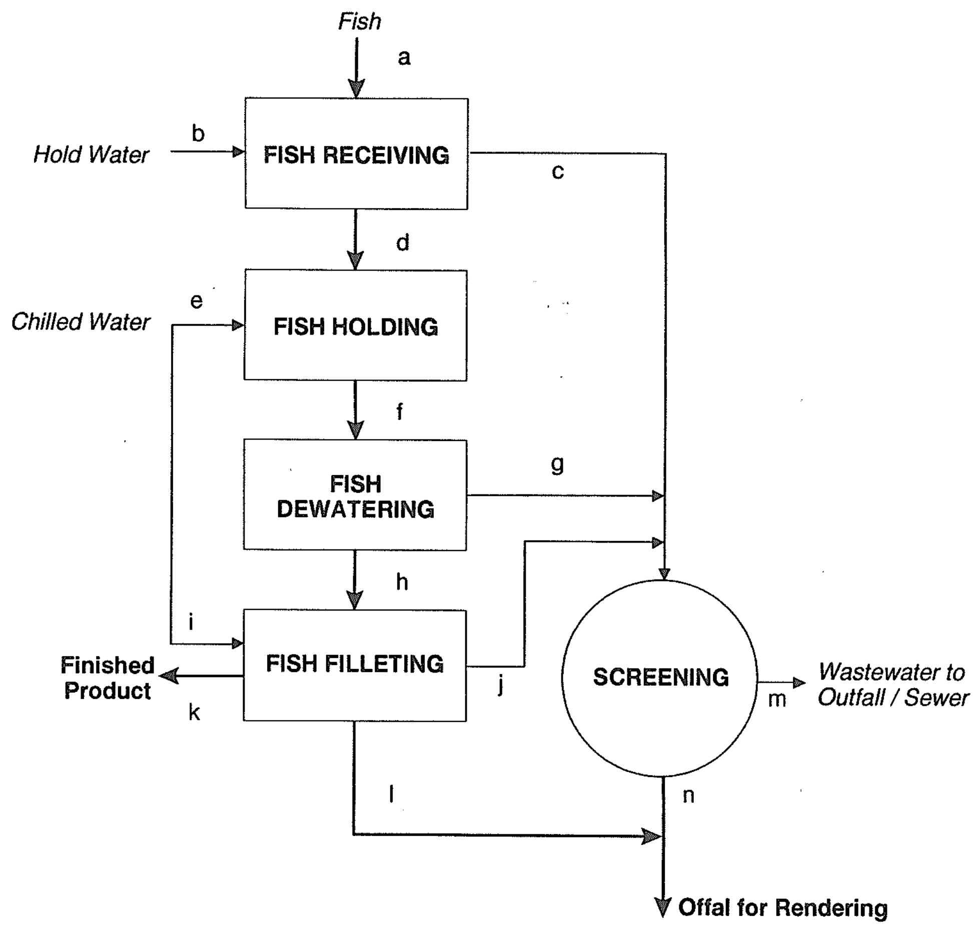
Figure 3. Steps of a Processing Plant Audit



Step 1. Create a Flow Sheet of the Plant

A flow sheet indicates the major components of a processing plant and assists in identifying the list of streams within the plant that require sampling. When creating a flow sheet, only include the areas of the plant that affect processing water and waste solids. Figure 4 is a sample flow sheet for an imaginary fish plant. The lower case letters identify plant streams that are discussed in Table 2 on page 6.

Figure 4. Sample Fish Plant Flow Sheet



Step 2. Make a List of Streams to Be Measured

The more streams that are sampled, the more accurate the results of the audit will be. In some cases, the list may have to be shortened if some of the streams are not accessible, or are located in an area that makes sampling hazardous. Streams to be measured could be ranked so that the largest and/or those with the most waste are a priority. Using Figure 4 on page 5, Table 2 below describes each of the streams to be measured.

Table 2. Stream Descriptions and Required Measurements from Figure 4.

STREAM	STREAM DESCRIPTION	WHAT TO MEASURE
a	Fish received to the plant	Weight (kg), Moisture Content (%)
b	Holding water that was transferred with the fish	Flow rate (litres/min) Waste Content (mg/l)
c	Fish receiving wastewater	Flow rate (litres/min) Waste Content (mg/l)
d	Dewatered fish to the Fish Holding Tank	Weight (kg), Moisture Content (%)
e	Chilled Water added to the Fish Holding Tank	Flow rate (litres/min)
f	Fish and Holding Water to Dewatering	Weight of fish (kg) Moisture Content of Fish (%) Flow rate of Holding Water (litres/min.) Waste Content of Holding Water (mg/l)
g	Wastewater from Fish Dewatering to Screening	Flow rate (litres/min) Waste Content (mg/l)
h	Dewatered Fish to Fish Filleting	Weight (kg), Moisture Content (%)
i	Chilled Water to Fish Filleting	Flow rate (litres/min)
j	Fish Filleting Wastewater to Screening	Flow rate (litres/min) Waste Content (mg/l)
k	Finished Product	Weight (kg), Moisture Content (%)
l	Solid Waste, or Offal, from Fish Filleting to Offal Rendering	Weight (kg) Moisture Content (%)
m	Wastewater to Outfall / Sewer	Flow rate (litres/min) Waste Content (mg/l)
n	Screened Solids to Rendering	Weight (kg), Moisture Content (%)

Step 3. Measure Flows and Concentrations

When and how each stream is measured can have a tremendous effect on the accuracy of the audit. Methods for measuring, calculating, and recording flow rates are outlined below. Appendix 1 outlines the recommended procedure for measuring flows for different stream types.

A. How to Measure Flow Rates

Flow rates are generally expressed in litres/minute for liquid streams and kilograms/minute for solid streams. When the flow rate should be measured and for how long is dependent on how the process runs. If the stream flow varies greatly, it is best to take more than one measurement and use the average to calculate the daily flow.

1. FLOW METERS

   When properly selected and installed, a flow meter is the best way to record flow rates. The cost and complexity of flow meters increases when the flow is very large and/or there are a lot of solids in the wastewater. Readings can be taken at a specific time and recorded, and some meters are equipped with a totalizer that automatically records the total flow rate. In some cases, it may be cost effective to rent an ultrasonic flow meter that straps onto the outside of the pipe. The meter can then be moved from pipe to pipe, throughout the plant. The accuracy of these flow meters is dependent on the type and diameter of pipe, the type of liquid in the pipe, and the flow rate.

2. BUCKET AND STOPWATCH

   This method is quick, inexpensive and limited to streams that are accessible and can be diverted to a pail or a drum. To employ this method, a container of known volume must be selected. The size of the container should be large enough that it takes at least 60 seconds to fill. If this is not practical, then a smaller container can be used, but the measurement should be repeated several times to ensure that the results are consistent. The following is an example of how the flow rate can be calculated using a bucket and a stopwatch. A 20 litre pail was placed at the end of a pipe, and it took 44 seconds to fill. The flow rate is:

   20 litres X 60 seconds / 44 seconds per minute = 27.3 litres/minute.

3. FLOW IN OPEN CHANNELS AND TROUGHS.

   Some plants have channel drains in the floor and/or troughs for fluming materials which may be difficult to check with the bucket method. Appendix 2 outlines the procedures for measuring channel drains in the floor and/or trough.

4. ESTIMATING FLOWS USING CHARTS AND GRAPHS.

   Flow can be estimated if the liquid being pumped completely fills the pipe through which it flows. If you can provide the pump manufacturer or sales agent with the make and model of the pump, the piping layout after the pump (i.e., the length and diameter of the pipe, number of fittings, height difference between the pump outlet and the end of the pipe where the flow is discharged), and the pressure in the pipe after the pump, he or she can estimate the flow rate using pump performance curves.

5. MANUFACTURER ESTIMATES / EDUCATED GUESSES

   This category for estimating flows is useful for streams that are hard to access, such as sprays inside a filleting machine. If you give the manufacturer of the filleting equipment the operating conditions of the machine, such as water pressure, he or she can usually provide an estimate for flow rates.

For streams that do not fall into any of the categories outlined, there is always the educated guess. This method can be verified using the Mass Balance procedure explained in Step #4 on page 12.

B. How to Measure Concetrations

When seafood comes in contact with water, some of the solids remain as solid particles and some of the solids dissolve into the water. Therefore, sampling is necessary to determine the quality and quantity of the waste in the stream. This is usually expressed as a concentration, as in milligrams of dissolved solid waste per litre of wastewater. Just as in measuring flow rates, there are some procedures that must be followed when measuring concentrations in order to get meaningful results. The content of each stream can vary in the same way that the flow rates can vary, and as a result, it is important to do some sampling before the audit to determine the extent of variability.

When determining concentrations, there are three parameters that are usually tested for:

1. BIOLOGICAL OXYGEN DEMAND (BOD)

   BOD is a measure of the amount of oxygen that is used by microorganisms to break down the organic material in the wastewater. This is an indication of how much organic matter or pollutants are in the wastewater.

2. TOTAL SUSPENDED SOLIDS (TSS)

   TSS is a measure of how much undissolved solids are in the wastewater.

3. TOTAL OIL AND GREASE (TOG)

   TOG is also known as FOG (Fats, oils, and grease) and is a measure of how much fish oil is in the wastewater.

If you plan on using the plant audit to determine the best end-of-pipe treatment method, there are two additional lab tests that should be done:

4. SOLUBLE BOD

   This is the measurement of the BOD due to the dissolved organic material. This measurement will help determine how much the BOD can be lowered by using less expensive treatment methods such as screening.

5. TOTAL DISSOLVED SOLIDS (TDS)

   A measurement of TDS helps to identify the quantity of solids dissolved in the wastewater. This further verifies the results of the soluble BOD test and, in some cases, can also indicate whether the solids are in contact with the water or wastewater for too long. In addition, a Mass Balance requires an estimate of the Total Solids in each stream which, in general, is the sum of TDS and TSS.

C. Sampling Methods

1. GRAB SAMPLES

   This method of sampling involves taking only one sample. If the content of the stream is constant, one sample may be sufficient, however, it is recommended that several grab samples be taken in order to increase accuracy.

   NOTE: Samples for TOG should only be taken as grab samples.

2. 24 HOUR COMPOSITE

   This method involves taking samples over a 24 hour period. This can be done either by taking grab samples every hour and analyzing them separately, or combining the 24 samples to make one composite sample. Ideally, several composites should be taken for accuracy. Automatic composite samplers are available which can be programmed to automatically draw samples and store them in one or individual bottles.

   NOTE: If there is very little consistency in the sample results, repeated sampling may be required in order to get a meaningful average.

D. Sampling Guidelines

- as quickly as possible, sample all the streams in the plant at the same time or one after the other;
- sample the streams during "normal" operation; and,
- measure the flow rates at the same time that the streams are sampled.

E. How to Collect Samples

Sampling procedures will vary depending on what the sample will be analyzed for. The laboratory employed to do the sample analysis can provide guidelines on how to sample, handle and ship the samples. The lab can also provide the necessary sample bottles and shipping coolers.

1. CONTAINERS

   Sample containers must be clean, with a tight fitting lid. It is best to use containers supplied by the laboratory.

   NOTE: Glass containers should always be used for the oil and grease analysis.

2. FILLING METHODS

   Containers should be filled completely and then sealed immediately. There are several filling methods depending on where the sample is taken:

   OPEN CHANNELS AND TROUGHS

   Samples should be taken along the centre of the trough or channel and several centimetres below the surface. The sample container should be removed as soon as it is filled to prevent solids from collecting and thereby affecting the value for suspended solids.

   SUMPS AND TANKS

   Because solids, oil, and grease may collect at the top or settle to the bottom of a sump or tank, samples should be taken at the centre of the sump or tank and several centimetres below the surface.

   PIPE DISCHARGE

   The sample container should be put into the stream and removed as soon as it is full.

   PIPES WITH NO OPEN DISCHARGE

   These pipes can only be sampled by installing a sample port. When installing this device, ensure that the port is located on the side (not the top or bottom) of the pipe. Also, the diameter of the port should be large enough to ensure movement of suspended solids and a valve (preferably a ball valve) should be installed that will not plug or obstruct the flow. The port should be allowed to flow for at least a minute before sampling to prevent any build up of solids.

   HIGH SOLID STREAMS

   In Figure 4 on page 5, the amount of dewatered fish to "Fish Filleting" would probably require collecting a number of fish in a given time period. The bucket, or tote of fish would have to be weighed on a scale. If flumes are used to collect offal, it will be difficult to get a representative sample because of the large fish parts. This may be one of the streams that cannot be analyzed for solids, but has to be calculated when doing the Mass Balance.

F. How to Handle Samples

Once the samples have been taken, they should be kept cold (but not allowed to freeze) and sent to the laboratory as soon as possible. If this is not done, the samples may break down and give false results. The procedure for handling samples is outlined in Table 3.

Table 3. Sample Handling Procedures

LAB TEST	TEMPERATURE	MAXIMUM HOLDING TIME
BOD	Keep cool, 4°C	48 hours
TSS	Keep cool, 4°C	7 days
Oil and Grease	Keep cool, 4°C, lower the pH to less than 2 using Sulphuric Acid	28 days

Source: Hach "Water Analysis Handbook", page 33

NOTE: The pH should only be lowered when the samples cannot be shipped to the lab within 24 hours. Consult with the laboratory on their preferred way of lowering the pH.

G. Sample Labelling

Proper sample labelling is very important. Every container should have a label or tag and a waterproof pen should be used for recording the following information:

- sample identification number;
- date and time the sample was taken;
- sample location; and
- name of the plant and person who took the sample.

All of the above information should also be recorded into an audit log book for future reference.

H. How to Select the Best Laboratory

In order to ensure that the samples are analyzed properly, select a laboratory that is certified and/or accredited by the Canadian Association for Environmental Laboratories Inc. This assures that the methods and procedures used by the laboratory have been verified according to Association standards. Some plants may want to save money and do the testing in-house. This is not advisable unless the plant has a properly equipped laboratory and trained technicians.

Step 4. Develop a Mass Balance

Creating a Mass Balance is similar to balancing a cheque book. In a Mass Balance, the total amount of water and seafood that enters the plant must equal the amount that leaves the plant. The Mass Balance helps ensure that there are no major errors in the measurements and estimations and that each stream is correctly identified in terms of flow rate and content. In general, if there is more than a 5-10% discrepancy in the Mass Balance, further sampling and flow measurements are recommended.

Figure 5 shows the flow sheet for a sample fish plant. The flow sheet illustrates fish, chilled water, and hold water streams coming into the plant and finished product, offal, and wastewater streams leaving the plant. Each area of processing has been numbered and corresponds to numbers on the Mass Balance in Table 4. All the water and solids going into the plant must equal the water and solids leaving the plant.

Figure 5. Sample Fish Plant Flow Sheet for Establishing a Mass Balance

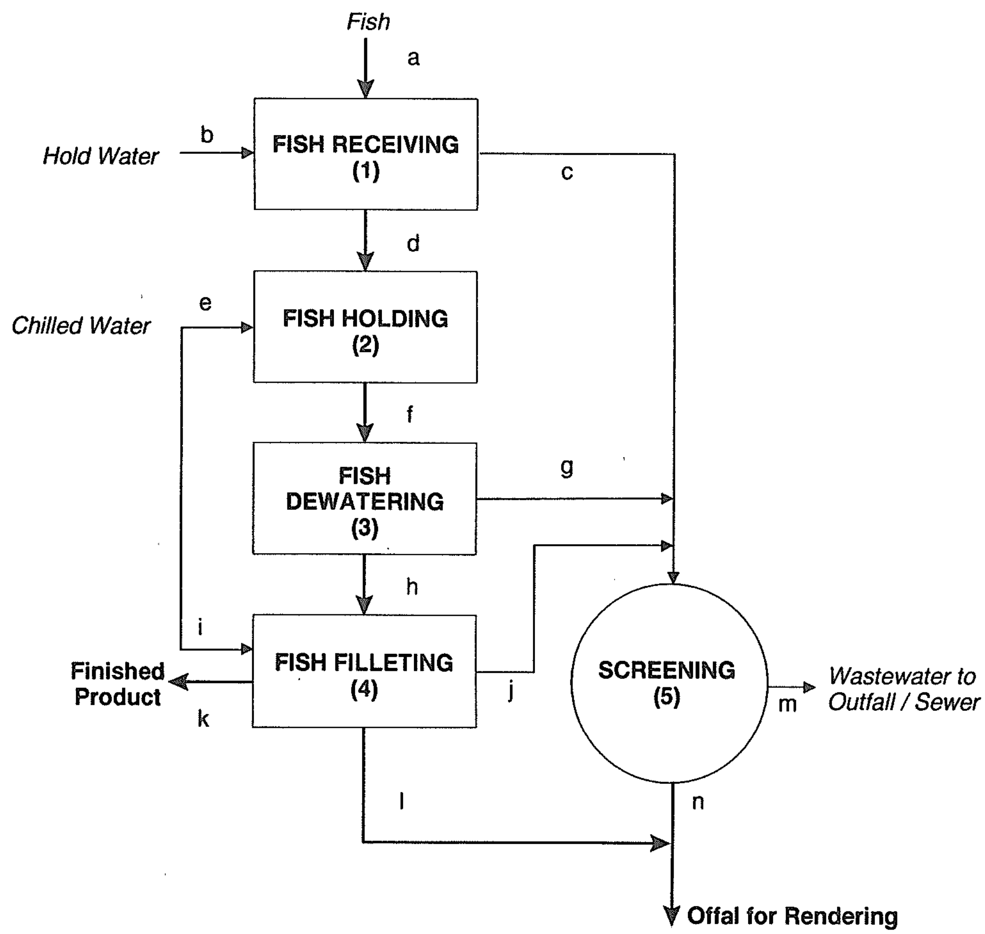


Table 4: Sample Mass Balance Spreadsheet

(1) FISH RECEIVING	FISH (a)	+	HOLD WATER (b)	=	FISH TO HOLDING (d)	+	WASTEWATER TO SCREENING (c)
TOTAL	100,000 kg		20,000 kg		10,000 kg		20,000 kg
DRY	18,020 kg		680 kg		18,000 kg		700 kg
WATER	81,980 kg		19,320 kg		82,000 kg		19,300 kg

(2)	FISH TO HOLDING (d)	+	CHILLED WATER (e)	=	FISH TO DEWATERING (f)
TOTAL					
DRY					
WATER					

(3)	FISH TO DEWATERING (f)	=	FISH TO FILLETING (h)	+	WASTEWATER To SCREENING (g)
TOTAL					
DRY					
WATER					

(4)	FISH TO FILLETING (h)	+	CHILLED WATER (i)	=	FINISHED PRODUCT (k)	+	OFFAL (l)	+	WASTEWATER TO SCREENING (j)
TOTAL									
DRY									
WATER									

(5)	WASTEWATER FROM FISH RECEIVING (c)	+	WASTEWATER FROM FISH DEWATERING (g)	+	WASTEWATER FROM FISH FILLETING (j)	=	RECOVERED SOLIDS (n)	+	WASTEWATER TO OUTFALL (m)
TOTAL									
DRY									
WATER									

A. Setting Up and Entering Data in the Mass Balance Spreadsheet

Using Figure 5 as the example, the Mass Balance sheet set up in Table 4 shows three components:

- the total flow — "Total"
- the amount of solids in the flow — "Dry"
- the amount of water in the flow — "Water"

The following shows how the sample Mass Balance has been completed for section number (1) "Fish Receiving".

A. FISH

For the imaginary plant, the first block in the Mass Balance spreadsheet might look like the following:

Total weight of fish to holding = 100,000 kg/day

B. HOLD WATER:

For this example, laboratory results may have been:

BOD = 1,500 mg/l

TSS = 1,010 mg/l

TDS = 33,000 mg/l

Oil & Grease = 25 mg/l

Therefore, Total Solids = TSS + TDS 1,010 mg/l + 33,000 mg/l = 34,010 mg/l

For calculating flow rate, plant data may have been:

Number of boats per day = 10

Litres of water transferred with the fish, per boat = 2,000 litres (l)

Total flow per day = 10 boats/day x 2,000 l/boat = 20,000 l/day

For the purposes of this example, the Mass Balance will be done over a 24 hour period to get a daily average. By using the laboratory results and the flow estimates, the following can be calculated:

Total Solids in the Hold Water = 34,010 mg/l of solids x 20,000 l/day = 680,200,000 mg/day or 680 kg/day of solids.

The total flow is 20,000 l/day, which can be assumed to be equivalent to 20,000 kg/day, therefore, the amount of water in this stream is:

20,000 kg/day(Total) – 680 kg/day(Dry Solids) = 19,320 kg/day

C. WASTEWATER TO SCREENING

For this example, it is assumed that the flow rate of wastewater to screening is the same as the hold water (20,000 kg or litres). If laboratory results indicate 35,000 mg/l total solids, the dry solids content is calculated to be:

35,000 mg/l of solids x 20,000 l/day = 700,000,000 mg/day or 700 kg/day of solids,

and the water content is:

20,000 kg/day – 700 kg/day = 19,300 kg/day

The values for the fish off-loaded from the boats can be calculated by:

Fish (a) = Fish To Holding (d) + Wastewater To Screening (c) – Hold Water (b).

D. FISH TO HOLDING:

It is easier to refer to published information on fish moisture content, than to try and analyze a whole fish [see The Chemistry and Technology of Pacific Fish by I.V. Kizevetter, 1971, Pacific Scientific Research Istitute of Marine Fishereis and Oceanography (TINRO)]. For a 10 kilogram fish, depending on the species, the moisture content may be 82%. This means that if the total weight of the fish is 10 kilograms, the water content is:

10 kg of fish x 0.82 kg water/kg of fish = 8.2 kg of water,

and, the amount of solids is:

10 kg of fish – 8.2 kg of water in the fish = 1.8 kg of dry solids in the fish.

Total solids, or dry matter = 100,000 kg/day x 18% dry matter = 18,000 kg/day

Total moisture, or water = 100,000 kg/day x 82% moisture = 82,000 kg/day

B. Calculating the Product Yield

Once the Mass Balance for each operation in the plant is completed, the product yield should be calculated. In the sample Mass Balance, this can be calculated as:

Finished Product (k), kg / Fish (a), kg x 100 = Percent Product Yield

Product yield can be increased by either:

- reducing the amount of raw material that becomes waste; or,
- converting waste into by-products (this yield would be calculated using finished product + by-product).

Increasing the amount of finished product that is produced for the same amount of raw material produces the greatest benefit. More product also means less waste and, therefore, less treatment cost.

Now that individual streams in the plant have been measured during normal operation and checked using the Mass Balance it is advisable to repeat the procedure during a plant clean up. An audit and Mass Balance should be done during this time especially if water use is being scrutinized.

Step 5. Classify the Streams by Flow Rate and Pollutant Load

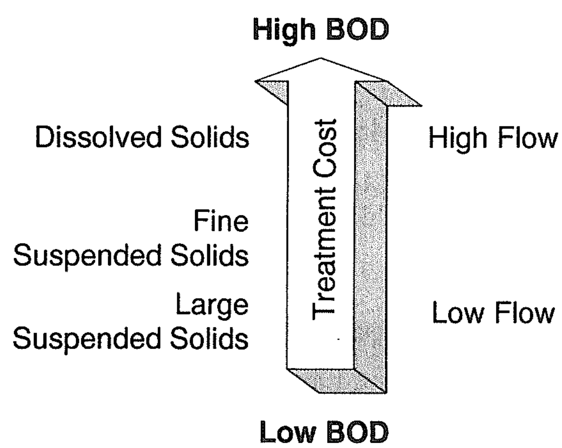
The next step in the audit process is to rank the plant streams according to their effect on wastewater treatment cost (Figure 6). This exercise is important for determining which streams should be attended to first when implementing efficiency measures. For normal operation and clean up, the streams should be classified into the following categories:

A. High Flow Rate
B. High Suspended Solids Load
C. High Dissolved Solids Load
D. High BOD Load
E. High Oil and Grease Load

NOTE: Some streams may be classified in more than one category.

Figure 6 shows how the different types of streams affect the cost of wastewater treatment.

Figure 6. How Streams Affect the Cost of Wastewater Treatment



A. High Flow Rate

Streams that fall into this category should be examined if water use and wastewater are to be reduced. In some cases, these streams may also represent the bulk of the pollutant level within the plant. Examples of this are outlined in Appendix 3.

Plants that pay a surcharge on wastewater based on concentration would not benefit from reducing flow rates. In general, however, lowering water use in plants also lowers the amount of pollutants in the wastewater. Depending on the plant, the concentrations may go up, but this increase will be proportionately less than the reduction in water use.

B. High Suspended Solids Load

Streams that fall into this category should be isolated from low pollutant streams and treated to remove the suspended solids. (Appendix 3.)

C. High Dissolved Solids Load

These streams contain pollutants that cannot be easily removed. Screening does not affect dissolved solids so every effort should be made to determine if the dissolved solids levels can be lowered by changing processing methods, waste handling practices or equipment.

D. High BOD Load

These streams contain a high pollutant load and additional sampling may be necessary to determine the level of soluble or dissolved BOD. If soluble BOD is low, most of the pollutants are in the form of suspended solids. These are generally easier to remove than if the level of soluble BOD is high. It is less expensive to make changes in the plant than to rely on end-of-pipe treatment to remove dissolved BOD.

E. High Oil and Grease Load

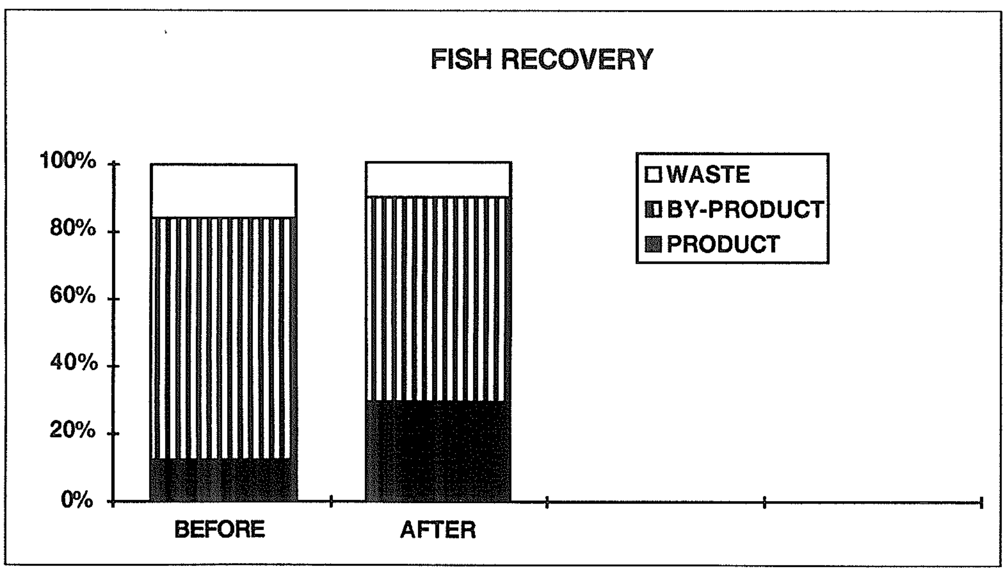
High levels of oil and grease can be a problem if screening is used for treating the stream because the screens may be prone to plugging up or "blinding." In some cases, more complex methods of treatment such as Dissolved Air Flotation (DAF) may be required to remove these pollutants. DAF is a chemical separation process in which the liquid wastewater is supersaturated with air.

Steps 6 and 7. Review and Modify Plant Equipment and Practices

Based on the results of the stream measuring and prioritizing, the next step is to improve plant equipment and procedures. Implementing the appropriate practices and technologies in the plant should result in less pollutants in the wastewater, greater product yield, and possibly more by-product recovery. This in turn will result in lower water, wastewater, equipment, and treatment costs, lower disposal costs for waste and wastewater and increased revenue through increased product yield.

Chart 1 shows the type of improvements that are possible. The actual percentages of increased efficiency depends on the type of plant and species processed.

Chart 1. Increased Efficiency for Fish Recovery



Step 8. Repeat the Audit Process After Each Plant Improvement

A plant audit is not a one-time event. Audits should be performed the first time in order to understand what is happening in the plant and after every major modification or improvement in order to measure the extent of the improvements. For example, if a modification in the plant involves changing what the operators are doing, an audit is an effective way to provide feedback regarding the procedure changes. If operators are requested to use shovels rather than hoses to remove solids from the floor, an audit can provide feedback on water usage. Or, if operators are requested to place catch basins under the processing equipment and empty them periodically into the offal bin, an audit can provide feedback on the amount of solid waste entering the floor drains. Once modifications and improvements have been made and assessed, audits should be performed on a regular basis in order to ensure that the plant is operating at peak performance.

In short, the audit process should be an integral part of doing business. Most businesses keep financial records on a monthly basis and may do a financial audit every year. Why should a plant audit be any different? Profitable seafood companies will find that the audit process is a valuable tool for fine tuning plant performance and efficiency.

Case Study

The Canadian Fishing Company of Vancouver processes herring and salmon. An audit was done in the plant in order to better understand the waste streams. The numbers that follow are only applicable to this plant, at the time that the audit was done, and are used here for illustration only.

Table 5. Audit Findings: Herring Wastewater

WASTEWATER STREAM	PERCENTAGE OF TOTAL FLOW		
Unloading and Slush Water	35%		
Thaw Water	25%		
Popping, Curing, and Clean-Up	40%		
LEVELS (mg/l)	**BOD**	**TSS**	**OIL/GREASE**
Hold Water	7,000	5,100	360
Thaw Water	3,000	300	70
Popping	3,100	2,400	140
Wash Brine	1,500	150	30

Table 6. Audit Findings: Salmon Wastewater

WASTEWATER STREAM	PERCENTAGE OF TOTAL FLOW		
Unloading Hold Water	5%		
Tote Slush Water	5%		
Conveyor Sprays	5%		
Butcher Flume	30%		
Gutter Flume	35%		
Cannery	10%		
Retort Cooling Water	10%		
LEVELS (mg/l)	**BOD**	**TSS**	**OIL/GREASE**
Hold Water	4,100	2,000	200
Slush Water	700	100	20
Butcher Flume	870	320	130
Gutter Flume	870	550	160
Cannery Flume	3,600	4,000	770
Blood Water	34,000	26,000	4,000

Table 7. Pre Audit Assumptions and Actual Audit Results

HERRING PROCESSING PRE-AUDIT ASSUMPTIONS	HERRING PROCESSING POST-AUDIT CONCLUSIONS
Vessel hold water considered to have the highest BOD and TSS levels	Vessel hold water had the highest BOD and TSS levels
Water used to slush herring in totes considered a major use of water and major wastewater volume	Water used to slush herring in totes accounted for a smaller fraction (5%) of total water usage than previously thought
Water used to thaw herring considered a major use of water and wastewater volume, but not considered to have a high BOD level	Largest single use of water was for thawing frozen herring, accounting for 25% of total water usage during herring processing, and had a high BOD level
Wastewater from herring "popping" and roe processing considered to have only moderate BOD & TSS levels	Popping, washing, and curing of roe, and general cleaning, represents a much larger proportion (40%) of total water usage than thought prior to the audit. Popping has second highest BOD and TSS levels
SALMON PROCESSING PRE-AUDIT ASSUMPTIONS	**SALMON PROCESSING POST-AUDIT CONCLUSIONS**
Vessel hold water considered to have the highest BOD and TSS levels	Blood water has the highest BOD and TSS levels
Water used to slush salmon in totes considered a major use of water and major wastewater volume	Tote slush water only accounts for 5% of wastewater
Water used for cooling cans considered a major use of water and wastewater volume, but not considered to have a high BOD level	Water used for cooling cans accounts for 10% of wastewater. Largest use of water was for butchering and gutting salmon for canning, accounting for 65% of total water usage during salmon processing
Wastewater from the cannery thought to have a high BOD & TSS level	Wastewater from cannery has third highest BOD level and second highest TSS level

A. Wasteful Practices Identified

- clean-up hoses left running and without nozzles;
- water used to melt discarded flake ice;
- equipment sprays and water flumes left operating during breaks;
- running water sprays on unused equipment;
- valves not being used to regulate water flow;
- excessive use of water in equipment sprays, conveyor sprays, and flumes; and,
- excessive water used during clean-up. For example, dry clean-up techniques not employed prior to wash-down of floors and equipment.

B. Design Modifications Identified

Design of butchering and gutting equipment needs to be re-evaluated from the perspective of water use and conservation.

Appendix I — When to Measure Flow Rates

Example 1: A Variable Plant Stream

In this example, the plant stream varies a great deal over a short period of time. The minimum flow is 300 litres/minute and the maximum is 650 litres/minute. Therefore, a number of measurements are necessary to obtain an average estimate of daily flow. Total flow for the day would be calculated:

CORRECT WAY TO ESTIMATE DAILY FLOW:

5 readings from 9:00 a.m. to 10:00 a.m. and average them:

(300+400+650+300+310)/5 = 392 litres/min.

The daily average flow would be:

392 litres/min. x 1,440 minutes/day = 564,480 litres/day

Example 2: A Sump Pump on a Timer

In this example, the flow cycles between 0 and 650 litres/minute. This is what would be expected for a sump pump on a 15 minute timer.

CORRECT WAY TO ESTIMATE DAILY FLOW:

The pump is on for 15 minutes and then off for 15 minutes. This means that it only runs 50% of the time at 650 litres/minute:

Minutes per day: 1,440

50% running time, minutes running per day: 1,440/2 = 720 minutes

650 litres/minute x 720 minutes/day = 468,000 litres/day

NOTE: If the cycle time was ignored, the wrong flow rate would be calculated:

WRONG WAY TO ESTIMATE DAILY FLOW:

Flow rate per day, assuming no cycle time:

650 litres/min. x 1,440 minutes/day = 936,000 litres/day

Example 3: Fluctuating Flow Rate

In cases where the flow rate fluctuates widely, it is important to take more than one reading and to average the results.

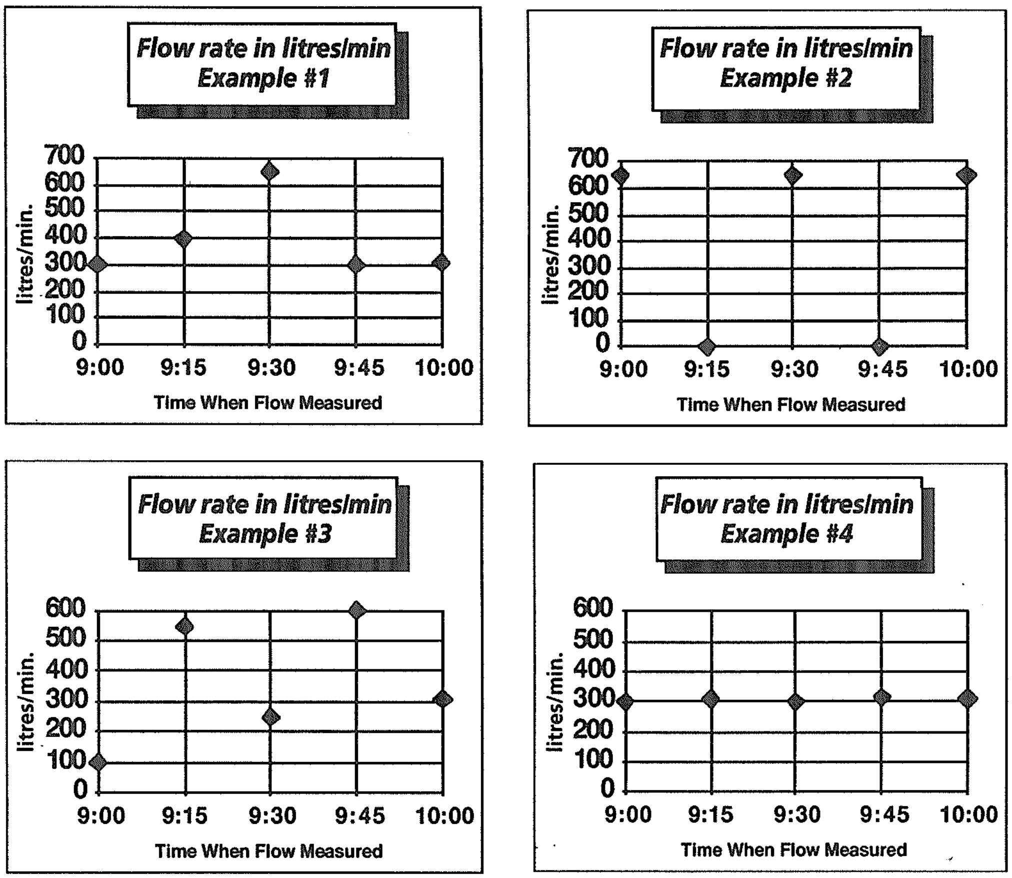
NOTE: Although this is acceptable for an audit, it may not be suitable for sizing wastewater treatment equipment.

Example 4: Stable Flow Rate

In cases where the flow rate does not vary substantially, single measurements and the average of several measurements will be very close.

The following illustrates strategies for determining flow rate under four different waste streams. In each case, measurements should be taken throughout the day before doing the audit in order to determine how many measurements are needed. Two other factors that can affect results are plant start up and shut down. These are generally not suitable times for taking measurements.

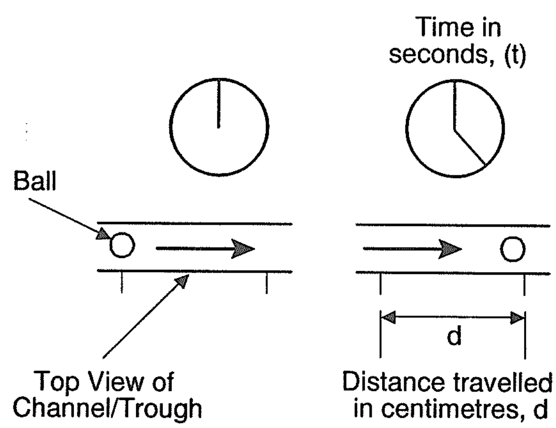
Table i. Flow Examples



Appendix 2 — Measuring Flow in Open Channel Troughs

1. Select, measure, and mark a section of the drain or trough that is easily visible from above.
2. Start a stopwatch and place a floating object (like a ping pong ball) on the surface of the wastewater at the first marker. When the ball reaches the second marker, record the time that it took to travel that distance. Looking down on the channel or trough, the process looks like that shown in Figure i.

Figure i. Calculating Velocity in a Channel Drain



The velocity V = d x t centimetres/second

In order to calculate flow, the area of the trough or channel will also have to be determined. You will need to measure the dimensions shown in the following figures. Figure ii shows the three types of channel construction while Table i outlines the required measurements for each channel type.

Figure ii. Three Types of Channel Construction

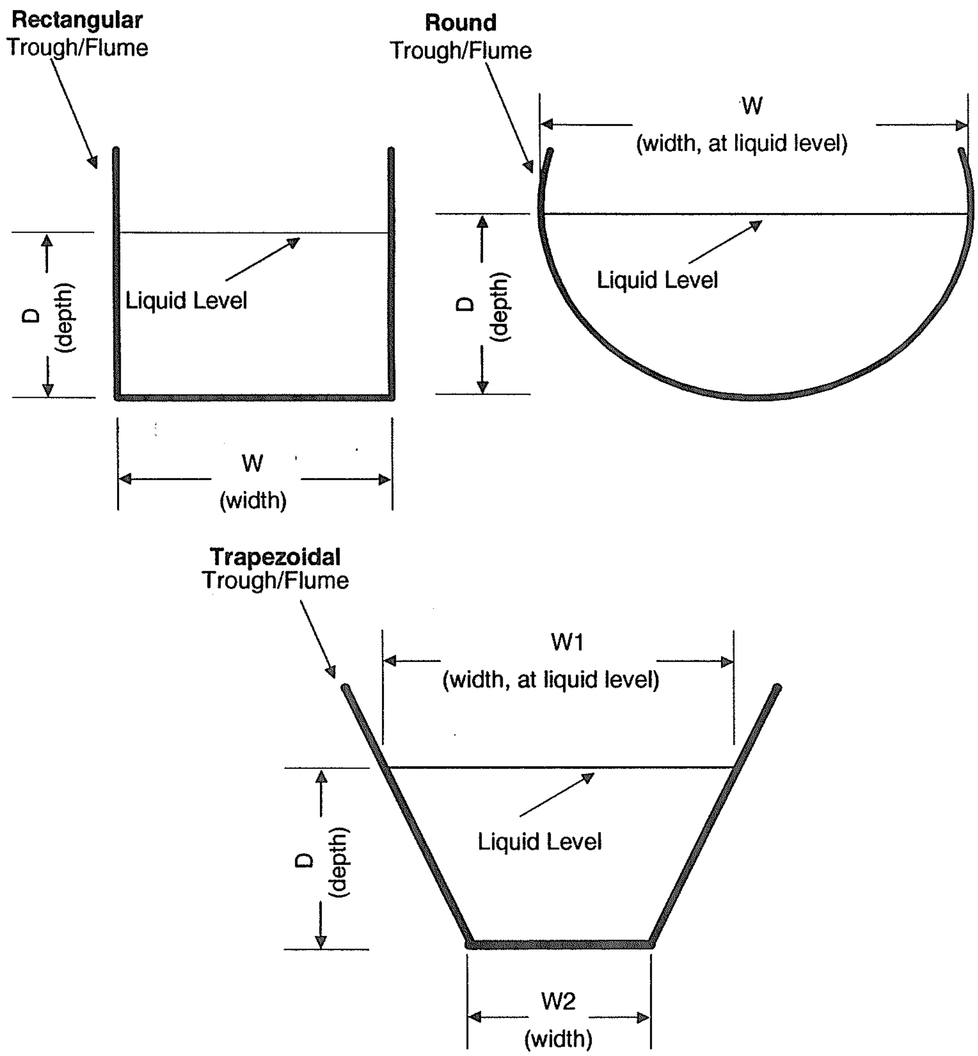


Table ii. Required Measurements for Each Channel Type

TROUGH/FLUME SHAPE	YOU WILL NEED TO MEASURE
Rectangular	Liquid depth (D) and trough/flume width (W).
Round	Liquid depth (D) and trough/flume width (W) measured across the liquid level.*
Trapezoidal	Liquid depth (D), trough/flume width (W1) measured across the liquid level, trough/flume width (W2).

NOTE: If two times the depth (D) is not equal to the width (W), you cannot easily use this method for calculating flow rate.

Using the velocity of the flow V (calculated previously) the flow rate can be calculated as follows:

Table iii: Trough/Flume Shape Calculations

TROUGH/FLUME SHAPE	CROSS SECTIONAL AREA (CSA)	FLOW (F), LITRES/MINUTE
Rectangular	CSA = W x D	F = CSA x V x 0.06
Round	CSA = 1.57 x D x D	F = CSA x V x 0.06
Trapezoidal	CSA = (W2+W1) x 1/2 xD	F = CSA x V x 0.06

NOTE:

1. If the material being collected foams excessively, it will be difficult to tell when the container is full. A small quantity of a food grade anti-foaming agent may have to be put into the container before filling.
2. If the liquid to be measured is under pressure or at an elevated temperature, the bucket and stopwatch method may not be advisable.

Appendix 3 — Examples of Stream Classifications

1) Flow rate versus BOD *as shown in the following example:*

Concentration can be misleading when the flow is very high. Low BOD concentration, for example, may also be a high contributor to BOD loading.

HIGHER FLOW / LOWER BOD

Stream A has a flow rate of 100,000 litres/day. The BOD is 1,500 mg/l.
On a daily basis, this would be:

100,000 litres/day x 1,500 mg/l /1,000,000 mg/kg = 150 kg BOD per day

LOWER FLOW / HIGHER BOD

Stream B has a flow rate of 10,000 litres/day. The BOD is 13,000 mg/l.
On a daily basis, this would be:

10,000 litres/day x 13,000 mg/l /1,000,000 mg/kg = 130 kg BOD per day.

In other cases, the opposite may be true. This is another reason why an audit can help you identify what the sources of wastewater and pollutants are in the plant.

2) The Effect of Mixing Streams with High and Low Total Suspended Solids (TSS)

Streams with a high TSS value should be isolated from streams with low TSS values.

Here is an example of what can happen if streams are mixed:

PART I:

Stream A is identified as a high suspended solids stream, with 2,500 mg/l TSS.

The flow rate is 600,000 litres/day.

If the stream is passed through a screen that has a 75% efficiency in removing suspended solids, the effluent will contain 625 mg/l TSS.

The screen removes 1,125 kg/day of solids.
The cost of the screen is $14,000.00

PART II:

Stream A is mixed with stream B that has a flow rate of 1,800,000 litres/day and only 75 mg/l TSS.

The new combined stream has a flow rate of 2,400,000 litres/day and 681 mg/l TSS.
Assuming the same screening efficiency, the effluent would contain 170 mg/l TSS.
The screen removes 1,226 kg/day of solids.
The cost of the screen is $21,000.00

The bottom line is that the screen in the second case had to be much larger to handle the combined flow rate. The screen cost 50% more, with only 9% more solids being recovered.

Appendix 4 — Plant Efficiency as a Function of Raw Material Processed

In the previous examples, streams were examined in terms of:

- **Concentration:** mg/l or milligrams of pollutant per litre.
- **Weight of pollutants** per day (kg/day)

A third method of interpreting the lab results involves relating the litres of water used and pollutants generated, to the weight of raw material processed. Consider these two examples:

Assume normal operation, with no clean up water between the two days shown:

Plant A processes 100,000 kg of fish on Day 1. They use 2,000,000 litres of water.

Plant A processes 55,000 kg of fish on Day 2. They use 1,265,000 litres of water.

Looking at these numbers, it appears that the plant used less water on Day 2. If the numbers are converted to how many litres of water is used per kilogram of fish processed; however, the numbers look like this:

Day 1: 2,000,000 l of water / 100,000 kg of fish = 20 litres of water / kg of fish.

Day 2: 1,265,000 l of water / 55,000 kg of fish = 23 litres of water / kg of fish.

Although the plant used less water to process less fish on the second day, the water use per kilogram of fish was greater. This indicates less efficient water use and conservation.

The same calculations can be done for pollutants, such as the kilograms of BOD, TSS, or Oil and Grease in the wastewater leaving the plant. It is important to relate these numbers to the kilograms of raw material processed. In this way, changes in efficiency can be spotted, even if the amount of raw material per day changes.